Cold Injury of Amputated Digits

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ABSTRACT

Cooling of amputated parts during transportation delays the onset of ischaemic tissue damage and contributes to successful replantation. The most common error in preservation of amputated parts is exposing them to temperatures, which may cause cold injury, and thus render them unusable. Two case reports will be presented, which illustrate how freezing cold injury (FCI) of amputated digits may decrease the viability of such digits following replantation, and discuss the potential benefit of hyperbaric oxygen therapy (HBOT) in treating FCI of amputated digits following replantation. During the period 1998 to 2002, 124 injured individuals with severed digits were admitted to the Department of Plastic Surgery and Burns at the Ljubljana Clinical Centre. During this period, the number of attempted replantations increased from 29% in 1998 to 48% in 2002. The success rate of these replantations was 81%. Cold injury to the amputated parts was a significant factor affecting the replantation success rate in six patients. In all these cases, all fingers with the exception of the thumb were severed, and placed on ice for preservation during the transportation to the hospital. In all cases, the amputated digits suffered FCI, which was noted after successful replantation. In one patient we assessed the benefit of administering HBOT to treat FCI of the replanted digits. Signs of FCI appeared three days after replantation. One patient received HBOT 7 days after replantation, whereas the others did not. Due to oedema and progressive necrosis observed in the replanted fingers of these patients, reamputation was necessary in most cases. The detrimental consequences of inappropriate preservation of the severed fingers at subzero temperatures were: non-freezing tissue damage, arterial and venous thrombosis during the microsurgical procedure, and longer operations. Post-operatively, improper preservation during transport caused complications associated with freezing- and non-freezing cold injury, despite successful reinstatement of perfusion to the replanted digits. Proper preservation of amputated body parts is essential for successful replantation. Hypothermic preservation is appropriate, if conducted properly. Since digits contain no muscle tissue, irreversible damage appears after significantly longer periods of ischaemia than in other types of tissue. Although we did not observe any benefit of HBOT in one patient, this is most likely due to the delay in initiating the treatment. HBOT should be administered immediately post-surgery, both to minimise reperfusion injury and freezing/non-freezing cold injury.

1.0 INTRODUCTION

Cooling of amputated parts during transportation delays the onset of ischaemic tissue damage and contributes to successful replantation. Current guidelines for a doctor, who refers a patient to a hospital for replantation surgery, are strictly defined. The amputated part should be wrapped in sterile moist (using Ringer lactate) gauze, then placed in a clean plastic bag and floated in a mixture of water and ice. The temperature of the mixture must be between 4 and 6 degrees Celsius. The stump should be protected with moist gauze and bandaged. The limb should be immobilized and elevated (Janezic and Arnez, 1998). Optimal conditions for hypothermic preservation of amputated digits are hard to attain in the field even

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when all the necessary equipment is available and the above guidelines are followed (Sapega et al., 1988; VanGiesen et al., 1983). The knowledge of the professional and lay public is insufficient. The most common error in preservation of amputated parts is exposing them to temperatures, which may cause cold injury, and thus render them questionable for replantation. The extent of tissue damage due to freezing is difficult to evaluate clinically. In the literature, hypothermic tissue injury is not listed as a contraindication to replantation surgery (Soucacos, 2001; Pederson, 2001; Gold and Lee, 1981). The surgeon is faced with a dilemma whether to replant or not. Most surgeons will attempt to replant the digit despite clinically obvious freezing injuries. A higher incidence of intra- and postoperative complications is noted in these cases. The replanted digit may be lost due to arterial and venous thrombosis in the immediate postoperative period. In this article, six cases will be presented, which illustrate how freezing cold injury (FCI) of amputated digits may decrease the viability of such digits following replantation, and discuss the potential benefit of hyperbaric oxygen therapy (HBOT) in treating FCI of amputated digits following replantation.

2.0 METHODS

During the period 1998 to 2002, in 6 of 124 admitted injured individuals the digits were brought frozen to the Department of Plastic Surgery and Burns at the Ljubljana Clinical Centre. Upon admission, the type of injury was assessed, and 18 of the 22 severed digits were replanted.

Due to the reported decrease in reperfusion injury and edema, and enhancement of rate of healing of problem wounds with hyperbaric oxygen (HBO) therapy, it was considered appropriate to include this therapy as an adjunct treatment, while one patient was hospitalised post-replantation. This patient received five daily 90 minute HBO treatments at 2.5 ATA in a multiplace hyperbaric chamber. The treatment was initiated 7 days after replantation.

3.0 RESULTS

In all cases, the amputated digits suffered FCI, which was noted after successful replantation. Signs of FCI appeared three days after replantation. Five of the 18 replanted digits remained viable, 13 had to be reamputated later.

In one patient we assessed the benefit of administering HBOT to treat FCI of the replanted digits. This patient received HBOT 7 days after replantation, whereas the others did not. Due to oedema and progressive necrosis observed in the replanted fingers of these patients, reamputation was necessary in most cases.

The detrimental consequences of inappropriate preservation of the severed fingers at subzero temperatures were: non-freezing tissue damage, arterial and venous thrombosis during the microsurgical procedure, and longer operations. Post-operatively, improper preservation during transport caused complications associated with freezing- and non-freezing cold injury, despite successful reinstatement of perfusion to the replanted digits.

4.0 DISCUSSION

We have found that success rate of replantation of amputated digits is significantly reduced by incorrect cooling of amputated digits during preoperative preservation. Because amputated digits are not warmed by inflow of arterial blood, they become frozen more quickly than perfused digits and are more susceptible to frostbite. Other factors that promote heat loss are contact with moisture or bare metal, high wind velocities, immobility and the small size of the amputated digit (Molnar et al., 1973; House and Fidler,

1993). A frozen digit is pale, hard and cool. More subtle hypothermic damage to the small blood vessels cannot be determined in the preoperative period. Additional tissue damage occurs during reperfusion (reperfusion injury). Vascular endothelium, bone and skin are most vulnerable. Vascular changes lead to thrombotic occlusion of arteries and veins, causing vascular spasms and subsequent diminished blood supply to the replanted digit (Mowlavi et al., 2003; Nakazato et al., 1986). In children, bone damage becomes evident 1-2 years after exposure to severe cold as stunted growth and destruction of epiphyseal growth cartilage, leading to flexion deformities of the fingers, radial deviation and anomalous fingernail growth (Nakazato and Ogin, 1986; Wenzel et al., 1967). Signs of oedema and epidermolysis are seen on the skin and subcutenous tissue. Progressive necrosis (demarcation) affects the skin, blood vessels, soft tissues and bones (VanGiesen et al., 1983; House and Fidler, 1993).

Therefore, proper preservation of amputated body parts is essential for successful replantation. Contrary to our previous experience with treating freezing cold injury with HBO, we did not observe any benefit of HBOT in the patient with replanted cold-injured digits. Most likely, this was due to the delay in initiating the treatment. Also, HBO therapy should be perhaps applied more aggressively (2 treatments daily) in the early phase of the healing process, and should be include a much greater number of treatments. The protocol used for treating acute traumatic peripheral ischaemias with HBO therapy should be evaluated in future studies. HBOT should be considered as an adjunct therapy and administered immediately post-surgery, both to minimise reperfusion injury and freezing/non-freezing cold injury.

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